On HBT parameters from high energy nuclear collisions - the λ parameter

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The space-time evolution information of high energy nucleus-nucleus collisions at freeze-out, i.e. when the hadrons cease to interact, can be extracted from the two-particle correlation function. [1] Parameterized in the out-side-longitudinal (osl) coordinate system, the correlation function is given as:

$$C_2(\mathbf{q}) = 1 + \lambda exp(-R_o^2 q_o^2 - R_s^2 q_s^2 - R_l^2 q_l^2), \quad (1)$$

where the components of relative momentum $\mathbf{q} = \mathbf{p}_1 - \mathbf{p}_2$ are defined parallel to the beam (l= longitudinal), parallel to the transverse momentum (o = out), and perpendicular to the transverse momentum (s = side). The λ is the chaoticity parameter or strength parameter and has the value of one in the ideal case[2]. Experimental results, as well as model calculations, often show that the value of λ is less than unity. A possible interpretation for the effect is partial quantum coherence, the final-state interactions, finite resolution in the momentum difference, and the resonances decay. A crucial question is what physics can we learn from the correlation measurements, specifically, from the λ-parameter? This is the focal point of the present report. In this work, pion correlation functions are derived from events generated by the relativistic quantum molecular dynamic model (RQMD) [3] to investigate the physics in the pion HBT λ-parameter.

Figure 1 shows the pion HBT λ-parameters as a function of freeze-out time in Au+Au central collisions at $\sqrt{s}$ = 200 $AGeV$. Due to expansion and/or resonance decay, the correlation functions are not in perfect Gaussian shape and the λ-parameter extracted from Eq. (1) is less than unity. However, within the time window of Δt = 10 fm/c, the correlation functions are much closer to the Gaussian shape and the λ is unity. In a time integrated window, ($\Delta t = 0 - t_i, t_i = 10, 20, 30...$ fm/c), the λ decreases and it eventually reaches the total time integrated value. This means that whence sequential freeze-out occurs, whether due to resonance decay or expansion, the summed source is not a Gaussian even it is at a given time interval. As a result, the correlation function is destroyed and the λ-parameter from the HBT measurement becomes less than 1. The experimental measured λ parameter is less than 1 may be interpreted as an evidence of sequential freeze-out in heavy ion collisions.

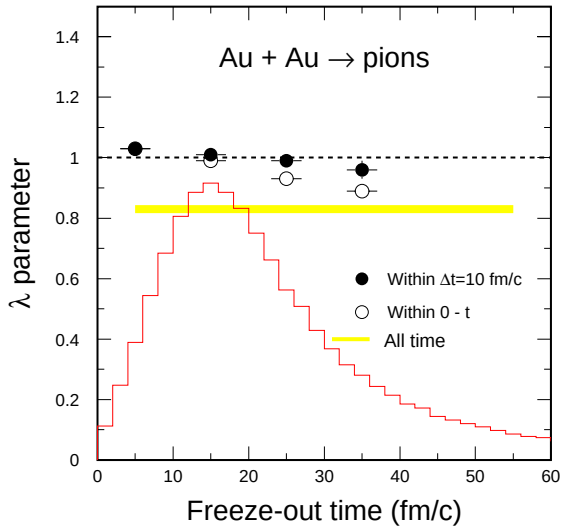

Figure 1: *The λ parameters as a function of freeze-out time in Au+Au central collisions at $\sqrt{s} = 200$ $AGeV$. The light histogram shows the pion time profile (arbitrarily normalized).*

Footnotes and References

[1] G. Baym, Acta Phys. Pol. B **29**, 1839 (1998); U. Heinz and B.V. Jacak, Ann. Rev. Nucl. Part. Sci. **49** (1999); and U.A. Wiedemann and U. Heinz, Phys. Reports, **319**, 145 (1999).

[2] G. Baym, *' Lectures on Quantum Mechanics'*, Benjamin, New York, 1969.

[3] H. Sorge, Phys. Rev. C **52**, 3291 (1995).